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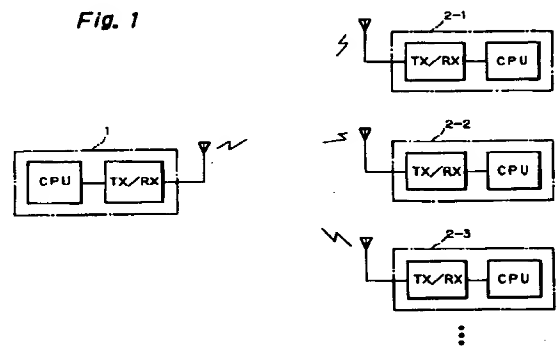
(54) Radio packet communication system capable of avoiding transmission collision

(57) In a radio packet communication system between a master station (1) and a plurality of slave stations (2-1 ~2-3), a contention mode is switched to a polling mode or vice versa in accordance with the amount of transmission data reserved by the slave stations to the master station.

Fig. 1



EP 0 773 651 A1

Description

The present invention relates to a radio packet communication system between a master station and slave stations, and more particularly, to a radio packet communication system capable of avoiding transmission collision of packets transmitted by the slave stations.

Description of the Related Art

In radio packet communication systems, there are a contention mode and a polling mode.

In the contention mode, a slave station having a transmission request transmits a reservation signal for requesting a transmission to a master station at a voluntary timing, and as a result, the master station gives an exclusive transmission right to the slave station in accordance with the reservation signal. In the contention system, since only slave stations having transmission requests can obtain exclusive transmission right, the transmission can begin immediately without having to wait. However, when the number of slave stations having transmission requests is increased, transmission collision between reservation signals may occur, so that a time required for obtaining the exclusive transmission right may become invalid.

On the other hand, in the polling mode, a transmission right for a reservation signal is sequentially allocated from the master station to all the slave stations. Therefore, there is no collision between transmission data from the slave station. However, since a transmission right for a reservation signal is allocated to slave stations having no transmission requests, a wait time may be required until slave stations having transmission requests obtain transmission rights, and also, an invalid time period for data transmission may occur.

In a prior art radio packet communication system, in order to effectively make use of both of the contention mode having no wait time and the polling mode having no collision, the contention mode is switched to the polling mode or vice versa in accordance with the occurrence of transmission collision between the slaves (see JP-A-5-48610).

In the above-mentioned radio packet communication system, however, switching between the contention mode and the polling mode is not smooth.

It is an object of the present invention to provide a radio packet communication system which can smoothly switch a contention mode to a polling mode or vice versa.

According to the present invention, in a radio packet communication system between a master station and a plurality of slave stations, a contention mode is switched to a polling mode or vice versa in accordance with the amount of transmission data reserved by the slave stations to the master station. Thus, in the contention mode, since the occurrence of transmission collision is anticipated in advance by the reserved transmission data, the contention mode can be smoothly switched to the polling mode. Conversely, in the polling mode, if the reserved transmission data is small, the polling mode can be switched to the contention mode.

The present invention will be more clearly understood from the description as set forth below, with reference to the accompanying drawings, wherein:

Fig. 1 is a diagram illustrating an embodiment of the radio packet communication system according to the present invention;
Fig. 2 is a flowchart showing the operation of the master station of Fig. 1;
Figs. 3A, 4A and 5A are also flowcharts showing the operation of the master station of Fig. 1;
Figs. 3B, 4B and 5B are diagrams showing the contants of Figs. 3A, 4A and 5A, respectively;
Figs. 6A through 6H are diagrams showing formats of access signals from the master station to the slave stations of Fig. 1;
Figs. 7A, 7B and 7C are diagrams showing formats of access signals from the slave stations to the master station of Fig. 1;
Fig. 8 is a sequence diagram showing the contention mode of FIg. 2; and
Fig. 9 is a sequence diagram showing the polling mode of Fig. 2.

In Fig. 1, which illustrates an embodiment of the present invention, reference numeral 1 designates a master station including a central processing unit (CPU) and a tranceiver, and 2-1, 2-2, 2-3, • • • designate slave stations each including a CPU and a transceiver.

The operation of the CPU of the master station 1 is shown in Fig. 2. That is, at step 201, it is determined whether or not a flag F is "0". The calculation of the flag F will be explained later in detail.

As a result, if F = "0", the control proceeds to step 202 which carries out a contention mode. Contrary to this, if F = "1", the control proceeds to step 203 which carries out a polling mode. The contention mode and the polling mode will also be explained later in detail.

Then, the control at steps 202 and 203 returns to step 201.

The flag F at step 201 of Fig. 2 is determined by one of the flowcharts of Figs. 3A, 4A and 5A, the operation shown therein being started by a timing when an amount of reservation signals transmitted by the slave stations 2-1, 2-2, 2-3, • • • reaches a predetermined value.

Referring to Fig. 3A, at step 301, an amount X of transmission data reserved by the slave stations 2-1, 2-2, 2-3, • • • is calculated.

Next, at step 302, it is determined whether or not $X < \alpha1$ is satisfied. Also, at step 303, it is determined whether or not $X > \alpha2$ is satisfied. In this case, $\alpha1 < \alpha2$. As a result, if $X < \alpha1$, the control proceeds to step 304 which resets the flag F, i.e., F = "0" (contention mode). Conversely, if $X < \alpha2$, the control proceeds to step 305

which sets the flag F, i.e., F = "1" (polling mode). Also, if $\alpha1 \leqq X \leqq \alpha2$, the control directly proceeds to step 306, and thus, the flag F is unchanged.

Thus, when the reserved transmission data amount X reaches $\alpha1$, the polling mode is switched to the contention mode. Also, when the reserved transmission data amount X reaches $\alpha2$, the contention mode is switched to the polling mode.

Note that, since the value $\alpha1$ is different from the value $\alpha2$, the flag F is controlled as shown in Fig. 3B, thus avoiding the chattering of the flag F. This stabilizes the communication operation.

Referring to Fig. 4A, at step 401, an amount Y of slave stations having an amount of reserved transmission data larger than a predetermined value is calculated.

Next, at step 402, it is determined whether or not $Y < \beta1$ is satisfied. Also, at step 403, it is determined whether or not $Y > \beta2$ is satisfied. In this case, $\beta1 < \beta2$. As a result, if $Y < \beta1$, the control proceeds to step 404 which resets the flag F, i.e., F = "0" (contention mode). Conversely, if $Y < \beta2$, the control proceeds to step 405 which sets the flag F, i.e., F = "1" (polling mode). Also, if $\beta1 \leqq Y \leqq \beta2$, the control directly proceeds to step 406, and thus, the flag F is unchanged.

Thus, when the slave station amount Y reaches β 1, the polling mode is switched to the contention mode. Also, when the slave station amount Y reaches $\beta2$, the contention mode is switched to the polling mode.

Note that, since the value $\beta1$ is different from the value $\beta2$, the flag F is controlled as shown in Fig. 4B, thus avoiding the chattering of the flag F. This stabilizes the communication operation.

Referring to Fig. 5A, at step 501, slave stations having an amount of reserved transmission data larger than a predetermined value are selected. Then, average amount Z of reserved transmission data for the selected slave stations is calculated.

Next, at step 502, it is determined whether or not $Z < \gamma1$ is satisfied. Also, at step 503, it is determined whether or not $Z > \gamma2$ is satisfied. In this case, $\gamma1 < \gamma2$. As a result, if $Z < \gamma1$, the control proceeds to step 504 which resets the flag F, i.e., F = "0" (contention mode). Conversely, if $Z < \gamma2$, the control proceeds to step 505 which sets the flag F, i.e., F = "1" (Polling mode). Also, if $\gamma1 \leqq Z \leqq \gamma2$, the control directly proceeds to step 506, and thus, the flag F is unchanged.

Thus, when the average reserved transmission data amount Z reaches $\gamma1$, the polling mode is switched to the contention mode. Also, when the average reserved transmission data amount Z reaches $\gamma2$, the contention mode is switched to the polling mode.

Note that, since the value $\gamma1$ is different from the value $\gamma2$, the flag F is controlled as shown in Fig. 5B, thus avoiding the chattering of the flag F. This stabilizes the communication operation.

Figs. 6A through 6H are diagrams of formats of access signals from the master station 1 to the slave stations 2-1, 2-2, 2-3, • • •. That is, a mode field 61, a control code field 62 and a slave station identification (ID) field 63 are provided. If the mode field 61 stores "0" as shown in Figs. 6B and 6C, the control mode is the contention mode; if the mode field 61 stores "1" as shown in Figs. 6D and 6E, the control mode is the polling mode; and if the mode field 61 stores "2" as shown in Figs. 6F, 6G and 6H, the control mode is a data transmission mode. In the contention mode, if the control code field 62 is "0" as shown in Fig. 6B, this means a reservation permission, and if the control code field 62 is "1" as shown in Fig. 6C, this means an acknowledgement of a reservation signal. Also, in the polling mode, if the control code field 62 is "0" as shown in Fig. 6E, this means an unused state, and if the control code field 62 is "1" as shown in Fig. 6F, this means a reservation permission. Further, in the data transmission mode, if the control code field 62 is "0" as shown in Fig. 6F, this means an unused state, if the control code field 62 is "1" as shown in Fig. 6G, this means a data transmission permission; and if the control code field 62 is "2" as shown in Fig. 6H, this means an acknowledgement of data reception.

Figs. 7A, 7B and 7C are diagrams of formats of access signals from the slave station 2-1, 2-2, 2-3, • • • to the master station 1, in which a control code field 71, a slave station ID field 72 and a data field 73 are provided. If the control field 71 is "0" as shown in Fig. 7B, this means a transmission reservation request, and if the control field 71 is "1" as shown in Fig. 7C, this means an actual data transmission.

The contention mode of Fig. 2 is explained next with reference to Fig. 8. In Fig. 8, only the slave stations 2-1 and 2-2 are illustrated and the other slave stations are omitted for simplifying the description.

First, the master station 1 generates a reservation permission signal S1 as shown in Fig. 6B and transmits it to the slave stations 2-1 and 2-2. As a result, the slave stations 2-1 and 2-2 generate transmission reservation request signals S2-1 and S2-2, respectively, associated with the bytes of transmitting data, as shown in Fig. 7B, and transmit them to the master station 1. In this case, as shown in Fig. 8, the transmission reservation request signal S2-1 collides with the transmission reservation request signal S2-2, and therefore, only one of the signals such as S2-1 is received by the master station 1. Thus, the master station 1 generates an acknowledgement signal S3-1 of the transmission reservation request signal S2-1 as shown in Fig. 6C, and transmits it to the slave station 2-1.

After a predetermined time has passed, the master station 1 again generates a reservation permission signal S1 as shown in Fig. 6B and transmits it to the slave stations 2-1 and 2-2. As a result, the slave station 2-2 generates a transmission reservation request signal S2-2, associated with the bytes of transmitting data as shown in Fig. 7B, and transmits it to the master station 1. Then, the master station 1 generates an acknowledgement signal S3-2 of the transmission reservation request signal S2-2 as shown in Fig. 6C, and transmits

it to the slave station 2-2.

Further, after a predetermined time has passed, the master station 1 generates a data transmission permission signal S4-1 as shown in Fig. 6G and transmits it to the slave station 2-1. Then, the slave station 2-1 generates a transmission data signal S5-1 as shown in Fig. 7C and transmits it to the master station 1. Finally, the master station 1 generates an acknowledgement signal S6-1 as shown in Fig. 6H and transmits it to the slave station 2-1.

Subsequently, the master station 1 generates a data transmission permission signal S4-2 as shown in Fig. 6G and transmits it to the slave station 2-2. Then, the slave station 2-2 generates a transmission data signal S5-2 as shown in Fig. 7C and transmits it to the master station 1. Finally, the master station 1 generates an acknowledgement signal S6-2 as shown in Fig. 6H and transmits it to the slave station 2-2.

Thus, in the contention mode, transmission right is sequentially allocated to the slave stations whose transmission reservation request signals are already received by the master station 1.

The polling mode of Fig. 2 is explained next with reference to Fig. 9. Also, in Fig. 9, only the slave stations 2-1 and 2-2 are illustrated and the other slave stations are omitted for simplifying the description.

First, the master station 1 generates a reservation permission signal, i.e., a polling signal S1'-1 as shown in Fig. 6D and transmits it to the slave station 2-1. As a result, if the slave station 2-1 has data to be transmitted to the master station 1, the slave station 2-1 generates a transmission reservation request signal S2'-1 associated with the bytes of transmitting data, as shown in Fig. 7B, and transmits it to the master station 1. Subsequently, the master station 1 generates a polling signal S1'-2 as shown in Fig. 6D and transmits it to the slave station 2-2. As a result, if the slave station 2-2 has data to be transmitted to the master station 1, the slave station 2-2 generates a transmission reservation request signal S2'-2 associated with the bytes of transmitting data, as shown in Fig. 7B, and transmits it to the master station 1. Subsequently, the master station 1 performs the same polling operation upon the other slave stations.

Subsequently, the master station 1 generates a data transmission permission signal S4-1 as shown in Fig. 6G and transmits it to the slave station 2-1. Then, the slave station 2-1 generates a transmission data signal S5-1 as shown in Fig. 7C and transmits it to the master station 1. Finally, the master station 1 generates an acknowledgement signal S6-1 as shown in Fig. 6H and transmits it to the slave station 2-1.

Also, the master station 1 generates a data transmission permission signal S4-2 as shown in Fig. 6G and transmits it to the slave station 2-2. Then, the slave station 2-2 generates a transmission data signal S5-2 as shown in Fig. 7C and transmits it to the master station 1. Finally, the master station 1 generates an acknowledgement signal S6-2 as shown in Fig. 6H and transmits it to the slave station 2-2.

The master station 1 performs the same data transmission operation upon the other slave stations.

Thus, in the polling mode, transmission right is sequentially allocated to all the slave stations.

As explained hereinabove, according to the present invention, since switching of the contention mode and the polling mode is carried out in accordance with the amount of transmission data reserved by the slave stations, such switching can be smoothly carried out.

Claims

1. A radio packet communication system comprising:

   a master station (1);
   a plurality of slave stations (2-1, 2-2, 2-3);
   a contention mode operating means (202) for performing a contention mode operation upon said master station and said slave stations;
   a polling mode operating means (203) for performing a polling mode operation upon said master station and said slave stations; and
   a switching means (201) for switching said contention mode operating means and said polling mode operating means in accordance with an amount of transmission data reserved by said slave stations to said master station.

2. The system as set forth in claim 1, wherein said switching means switches said polling mode operating means to said contention mode operating means when the amount of transmission data is small, and said switching means switches said contention mode operating means to said polling mode operating means when the amount of transmission data is large.

3. The system as set forth in claim 1 or 2, further comprising:

   means for calculating the amount (X) of transmission data reserved by said slave stations to said master station every time a number of reservations by said slave stations reaches a predetermined value;
   means for determining whether or not the amount of transmission data is smaller than a first value ($\alpha 1$); and
   means for determining whether or not the amount of transmission data is larger than a second value ($\alpha 2$) larger than said first value,
   said switching means switching said polling mode operating means to said contention mode operating means when the amount of transmission data is smaller than said first value,
   said switching means switching said contention mode operating means to said polling mode

operating means when the amount of transmission data is larger than said second value.

4. The system as set forth in any of claims 1 to 3, further comprising:

means for calculating a number (Y) of slave stations having an amount of reserved transmission data larger than a predetermined value at every time when a number of reservations by said slave stations reaches a predetermined value;
means for determining whether or not said number of slave stations is smaller than a first value ($\beta 1$); and
means for determining whether or not said number of slave stations is larger than a second value ($\beta 2$) larger than said first value,
said switching means switching said polling mode operating means to said contention mode operating means when the amount of transmission data is smaller than said first value,
said switching means switching said contention mode operating means to said polling mode operating means when the amount of transmission data is larger than said second value.

5. The system as set forth in any of claims 1 to 4, further comprising:

means for selecting slave stations having an amount of reserved transmission data larger than a predetermined value every time a number of reservations by said slave stations reaches a predetermined value;
means for calculating an average amount (Z) of reserved transmission data for said selected slave stations;
means for determining whether or not said average amount of transmission data is smaller than a first value ($\gamma 1$); and
means for determining whether or not said average amount of transmission data is larger than a second value ($\gamma 2$) larger than said first value,
said switching means switching said polling mode operating means to said contention mode operating means when the amount of transmission data is smaller than said first value,
said switching means switching said contention mode operating means to said polling mode operating means when the amount of transmission data is larger than said second value.

Fig. 1

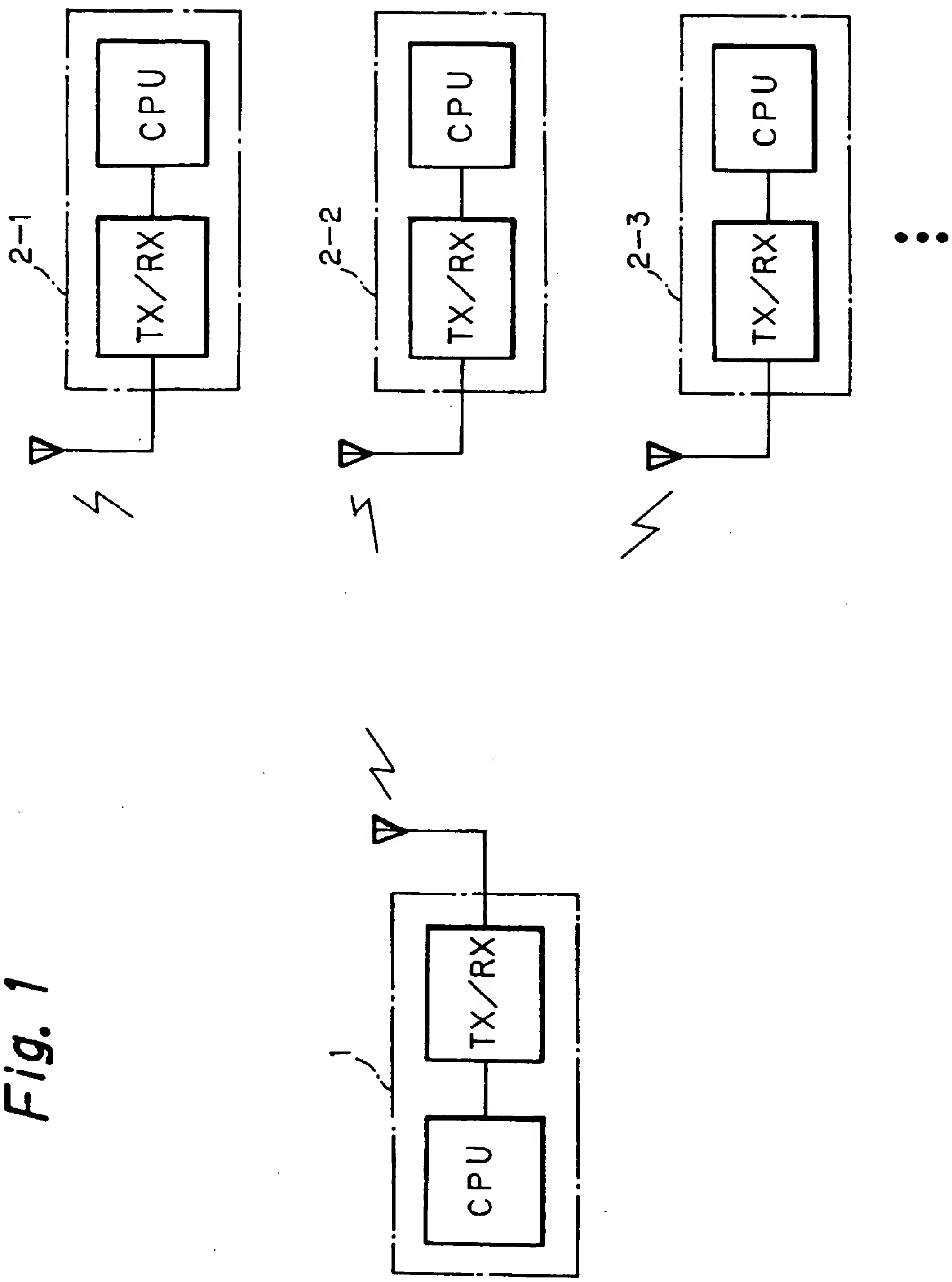


Fig. 2

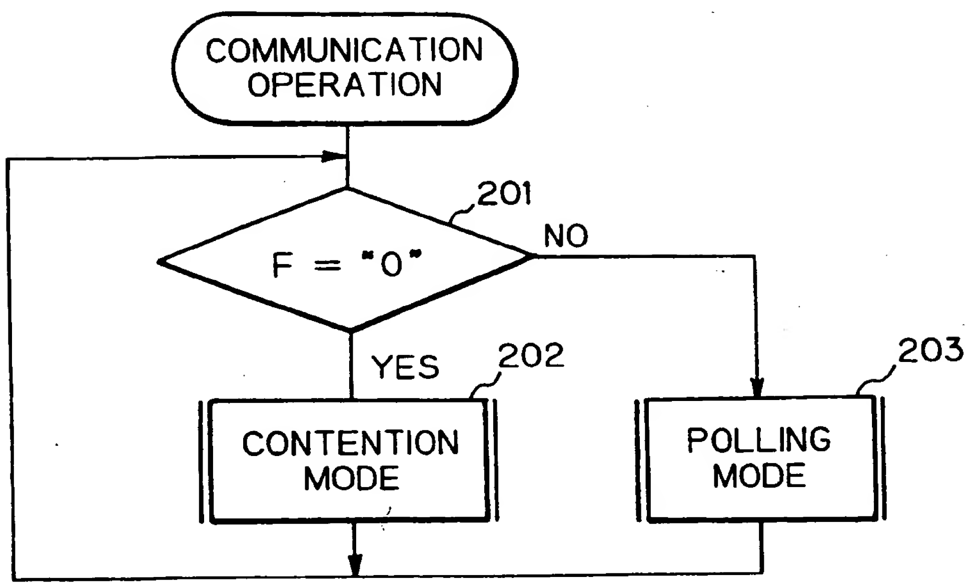

COMMUNICATION OPERATION
201
F = "0"
NO
YES
202
203
CONTENTION MODE
POLLING MODE

Fig. 3A

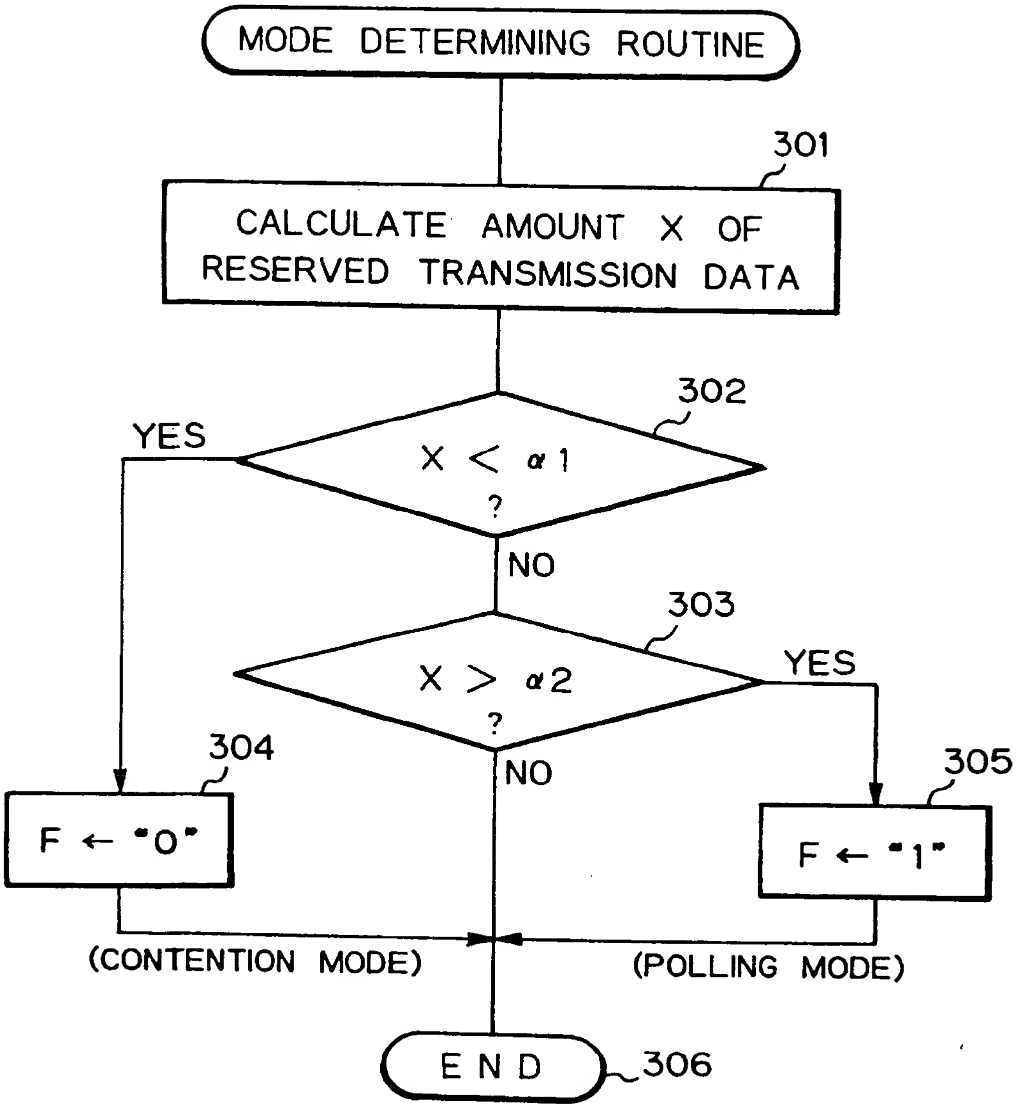

MODE DETERMINING ROUTINE
301
CALCULATE AMOUNT X OF RESERVED TRANSMISSION DATA
302
X < α1 ?
YES
NO
303
X > α2 ?
YES
NO
304
F ← "0"
305
F ← "1"
(CONTENTION MODE)
(POLLING MODE)
END
306

Fig. 3B

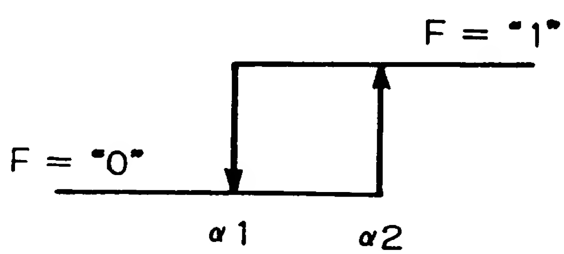

F = "1"
F = "0"
α1
α2

Fig. 4A

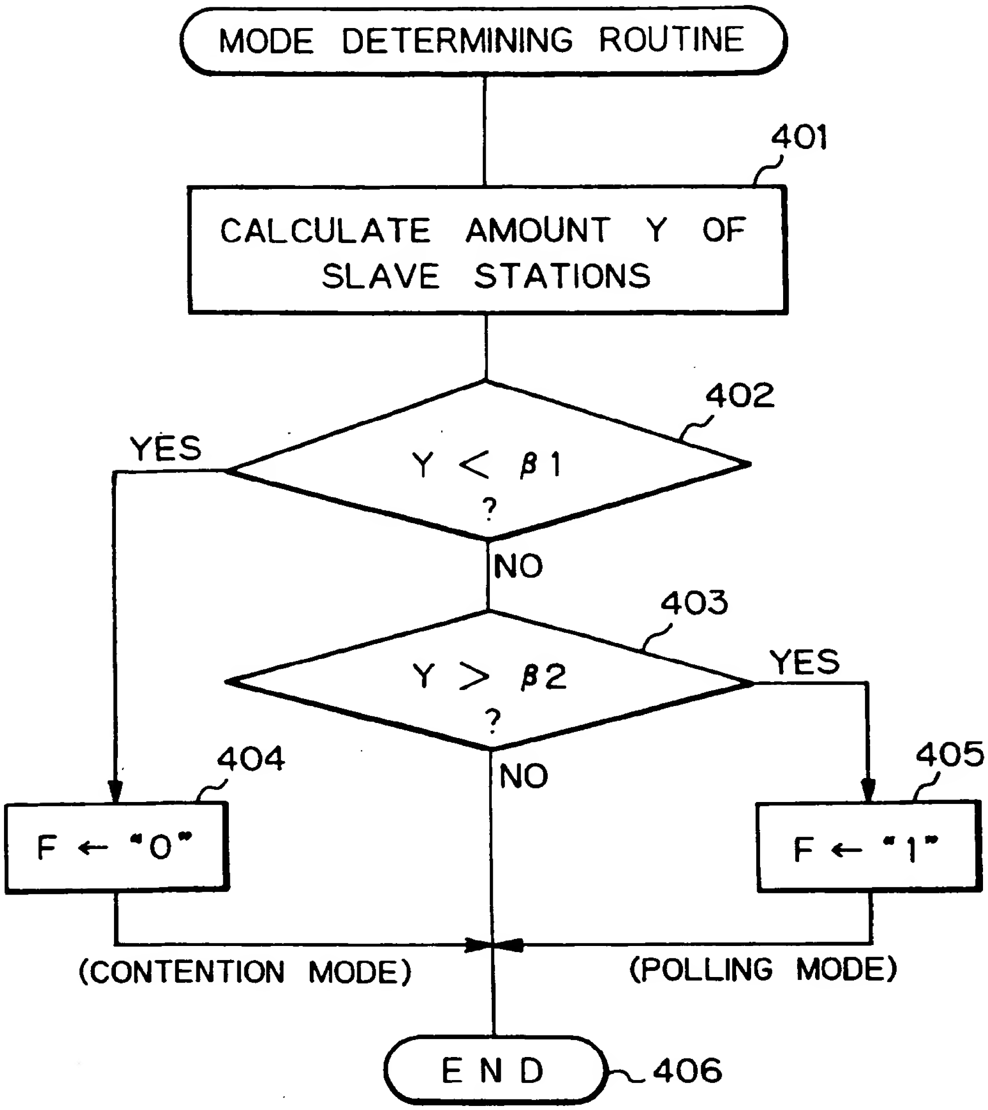

MODE DETERMINING ROUTINE
401
CALCULATE AMOUNT Y OF SLAVE STATIONS
402
Y < β1 ?
YES
NO
403
Y > β2 ?
YES
NO
404
F ← "0"
405
F ← "1"
(CONTENTION MODE)
(POLLING MODE)
END
406

Fig. 4B

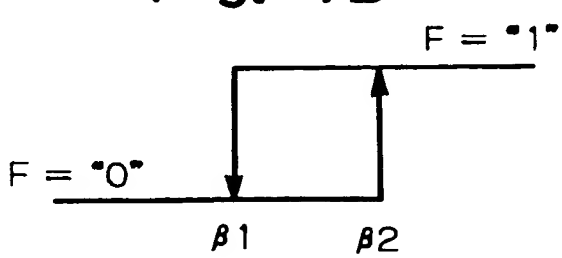

F = "1"
F = "0"
β1
β2

Fig. 5A

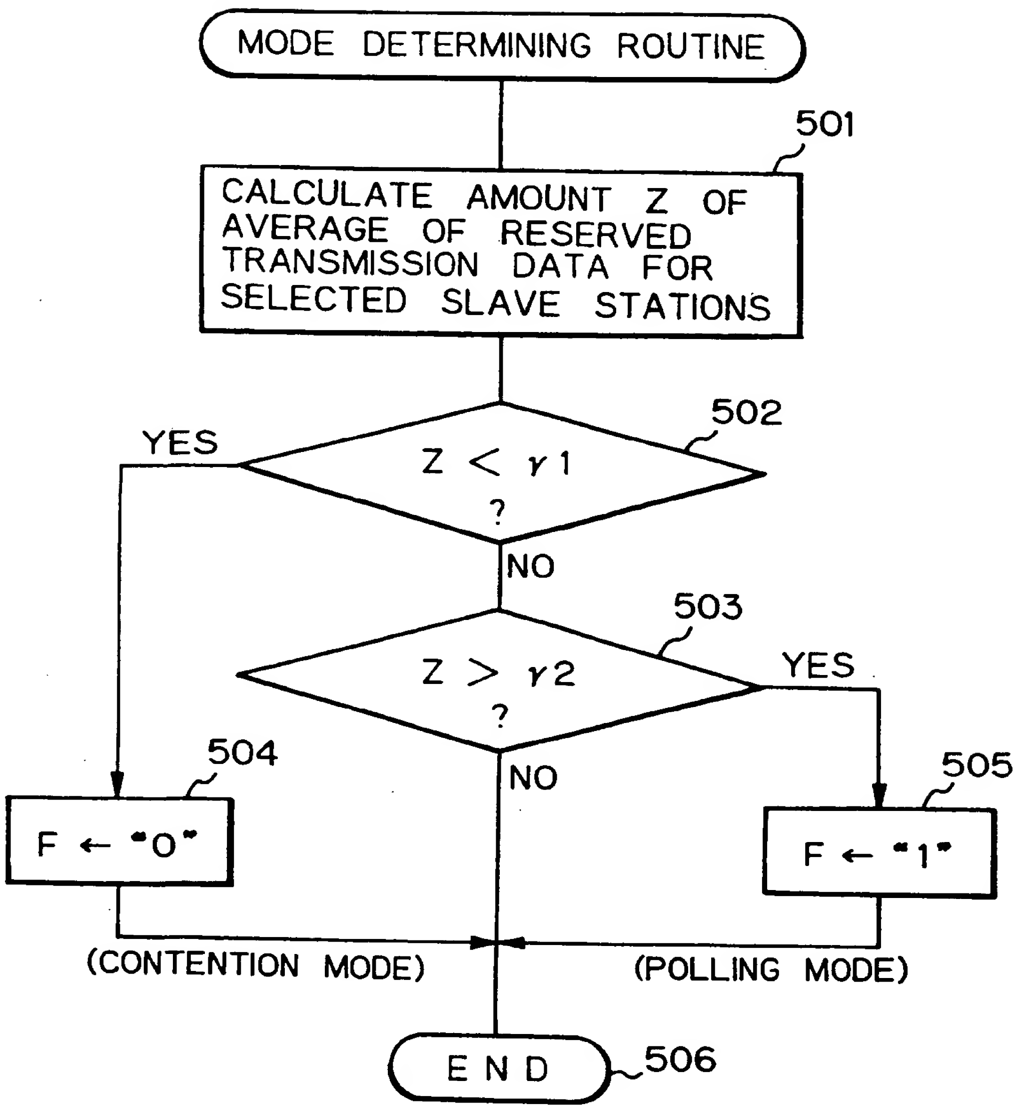

MODE DETERMINING ROUTINE
501
CALCULATE AMOUNT Z OF AVERAGE OF RESERVED TRANSMISSION DATA FOR SELECTED SLAVE STATIONS
502
YES
Z < γ1 ?
NO
503
Z > γ2 ?
YES
NO
504
F ← "0"
505
F ← "1"
(CONTENTION MODE)
(POLLING MODE)
END
506

Fig. 5B

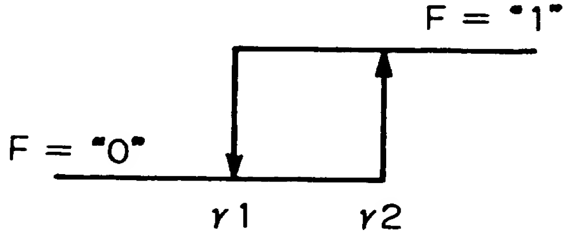
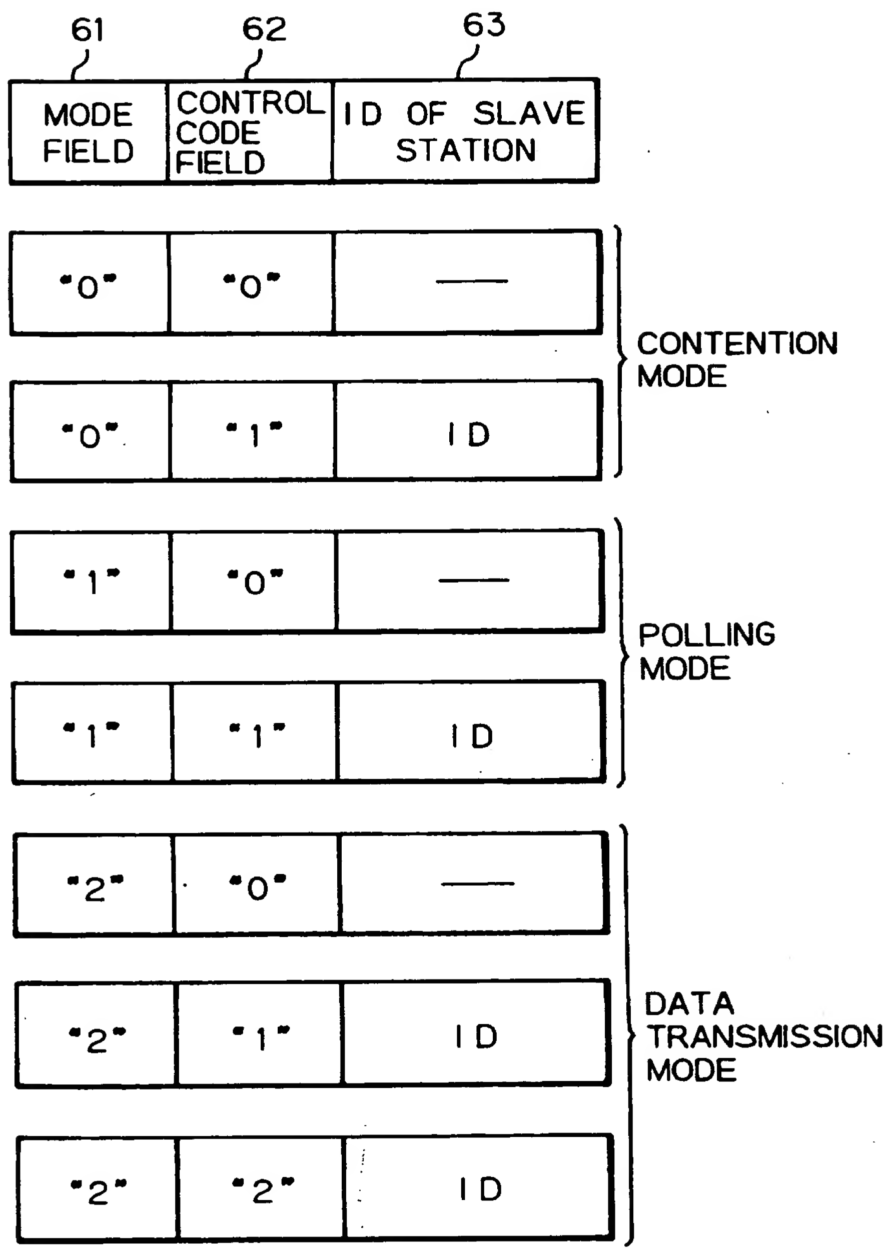

F = "1"
F = "0"
γ1
γ2

Fig. 6A
Fig. 6B
Fig. 6C
Fig. 6D
Fig. 6E
Fig. 6F
Fig. 6G
Fig. 6H



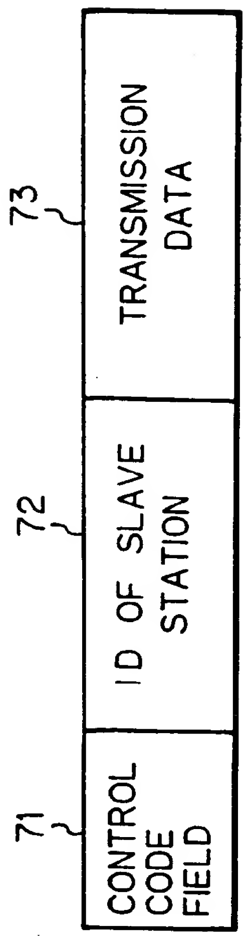


Fig. 7A

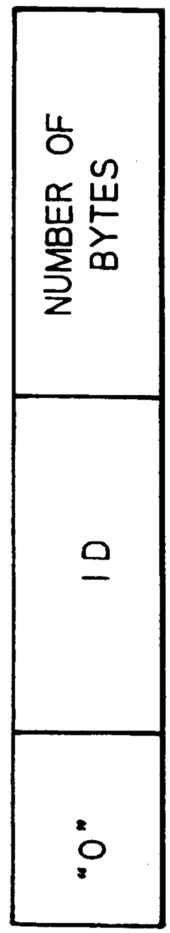


Fig. 7B

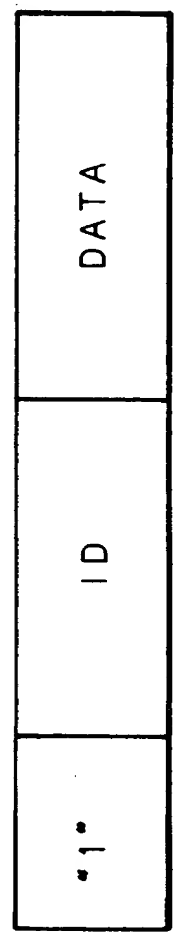


Fig. 7C

Fig. 8

CONTENTION MODE

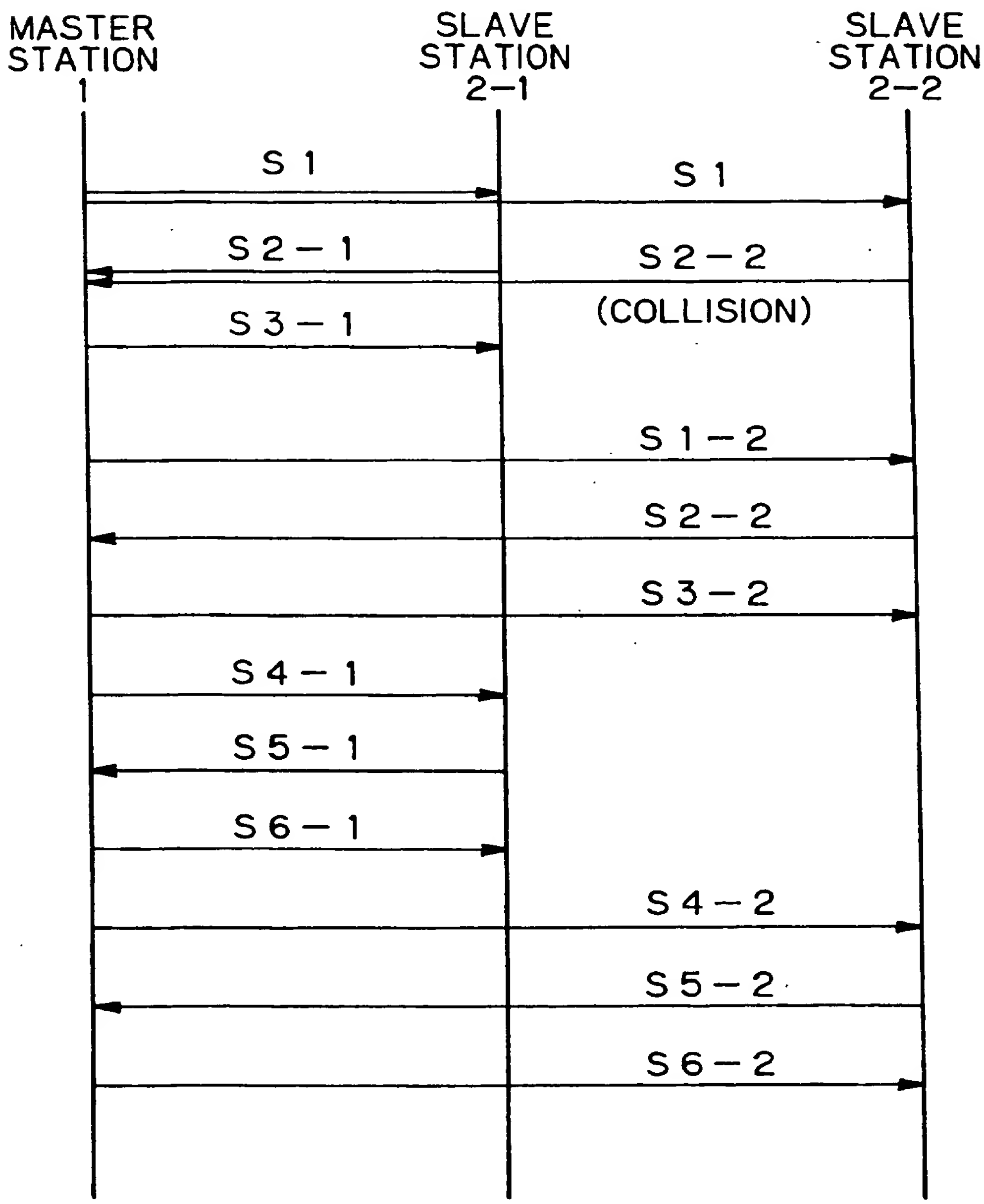
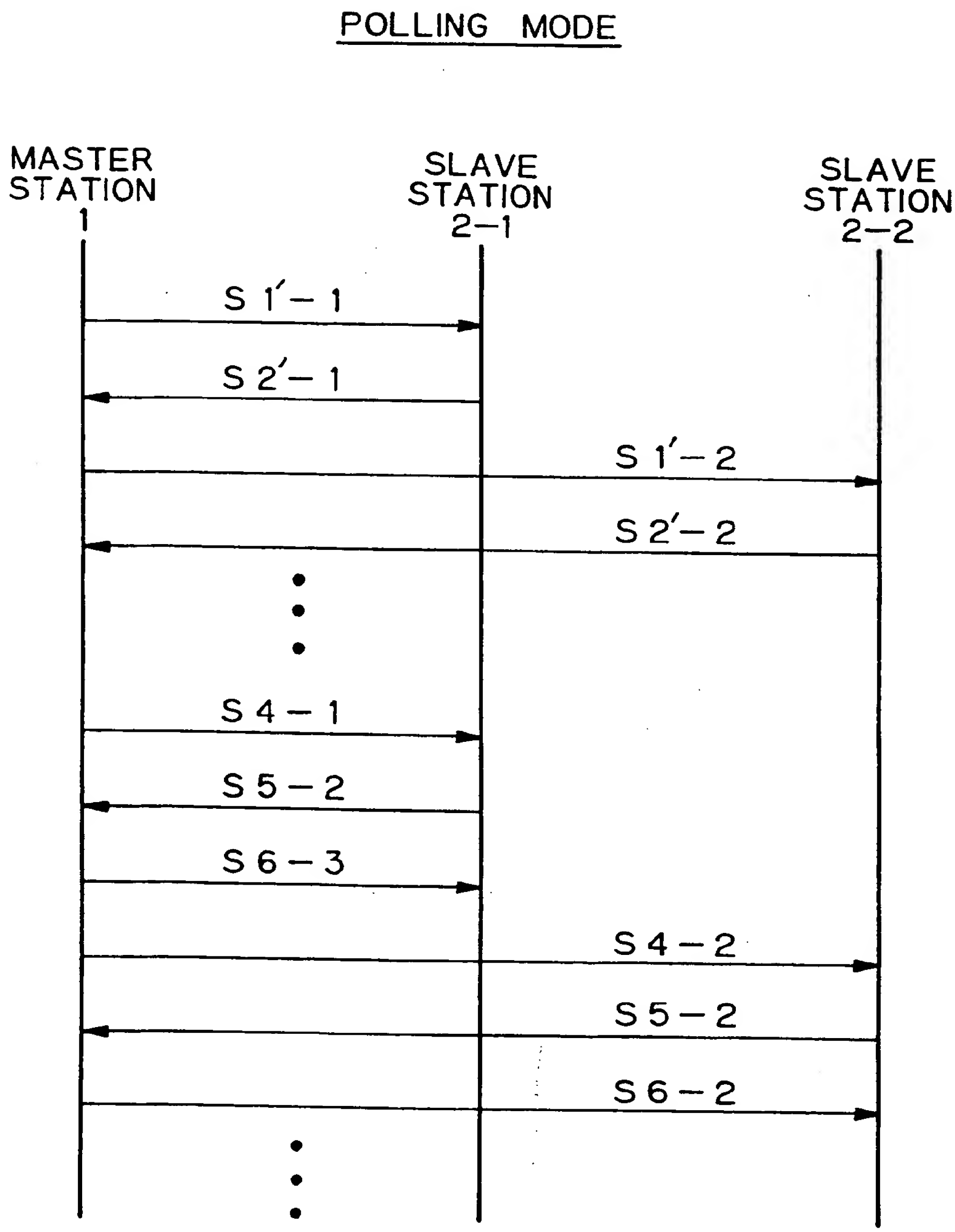


Fig. 9


POLLING MODE
MASTER STATION 1
SLAVE STATION 2-1
SLAVE STATION 2-2
S 1′- 1
S 2′- 1
S 1′- 2
S 2′- 2
S 4 - 1
S 5 - 2
S 6 - 3
S 4 - 2
S 5 - 2
S 6 - 2

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 7931

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y A	WO-A-91 16775 (TELXON CORPORATION) 31 October 1991 * page 1, line 5 - page 4, line 17 * * page 7, line 14 - line 33 * ---	1,2 3-5	H04L12/56 H04L12/403
Y A	EP-A-0 321 454 (PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED) 21 June 1989 * column 3, line 18 - column 4, line 13 * * column 5, line 35 - column 6, line 35 * * column 7, line 34 - column 8, line 5 * ---	1,2 3-5	
A	IEEE MILITARY COMMUNICATIONS CONFERENCE, vol. 3, 30 September 1990 - 3 October 1990, MONTEREY, CA, pages 934-938, XP000221657 RICHARD C. SUNLIN: "A Hybrid Distributed Slot Assignment TDMA Channel Access Protocol" * page 934, left-hand column, line 1 - right-hand column, line 13 * ---	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H04L
A	US-A-5 012 469 (SARDANA) 30 April 1991 * column 4, line 12 - line 62 * * column 7, line 63 - column 8, line 55 * * column 12, line 42 - column 13, line 37 * * column 16, line 20 - line 44 * ---	1-5	
A	EP-A-0 286 134 (FUJITSU LIMITED) 12 October 1988 * page 2, line 6 - line 10 * * column 2, line 44 - column 3, line 40 * -----	1-5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	12 February 1997	Vaskimo, K

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